

# Time Reversal Invariance Violation in Polarized Neutron Beta Decay

*S. J. Freedman, B. K. Fujikawa, L. J. Lising, E. G. Wasserman, and the emiT Collaboration*

Evidence for CP violation and its implied consequence: T violation has been established in the neutral kaon system. Although there have been many searches for T violation in other systems, it has yet to be observed. The goal of the emiT experiment is to search for possible T violation in the beta decay of free polarized neutrons. This experiment is designed to detect a correlation of the form,

$$D \hat{\sigma}_n \cdot (\vec{p}_e \times \vec{p}_v)$$

which is odd under time reversal. A non-zero\* triple correlation coefficient,  $D$ , would imply T violation. Several measurements of the  $D$ -coefficient were made and the current world average is  $D = -(0.5 \pm 1.5) \times 10^{-3}$  consistent with zero. The first run of the emiT experiment was conducted at the National Institute of Standards and Technology (NIST) Cold Neutron Research Facility (CNRF). The experimental apparatus, shown in Fig. 1, utilizes an octagonal array of detectors to observe, in coincidence, electrons and recoil protons from neutron beta decay. The neutrons in the cold ( $T=40$  Kelvin) beam are polarized to 96% with a supermirror polarizer. Electrons are detected with four 50-cm long plastic scintillators. The recoil protons, whose maximum energy is less than 750 eV, are accelerated by a 36 kV potential onto thin window PIN diodes. The characteristic delay time between the decay proton and electron is used to distinguish signal from background. The proton drift time is greater than  $0.5 \mu\text{s}$  and most backgrounds are prompt. Anticipated sources of systematic uncertainty were reduced in the detector design and measurements were made to assess the effect of certain crucial factors. The high neutron polarization and the high acceptance of the detector give this experiment a significant improvement in sensitivity over previous experiments. The analysis of the data taken from the first emiT run has been completed [1,2]. The result,  $D = -(0.1 \pm 1.3) \times 10^{-3}$  is consistent

with zero. This value represents a small improvement over the current world average. A manuscript describing the experiment and this result in detail is almost complete and will be submitted to the Physical Review C in February, 2000 [3]. The emiT collaboration is currently planning second run at the NIST CNRF with strategies to overcome limitations experienced in the first run. With these improvements in place, it is feasible to push the statistical uncertainty to the  $3 \times 10^{-4}$  level.

## Footnotes and References

\*The participating institutions of the emiT collaboration are: Lawrence Berkeley National Laboratory, University of California at Berkeley, University of Michigan, National Institute of Standards and Technology, Notre Dame University, Los Alamos National Laboratory, and University of Washington.

\*Above final state interactions (FSI):  $D_{\text{FSI}} = -5.7 \times 10^{-5}$ .

1. S.-R. Hwang, Ph.D. thesis, Univ. of Michigan, (1998).
2. L. J. Lising, Ph.D. thesis, Univ. of California (1999).
3. L. J. Lising, *et al.*, to be submitted to Phys. Rev. C.

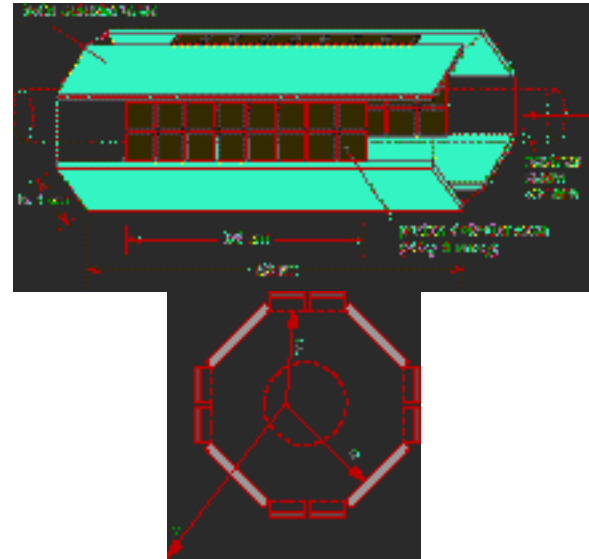


Fig. 1. Artist's conception of the basic detector geometry: an octagonal array of four each proton and electron detectors.